

# MALARIA

THE BATTLE  
AGAINST A  
MICROSCOPIC  
KILLER



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JAMIE HALL AND EDWARD ROSS, 2012.

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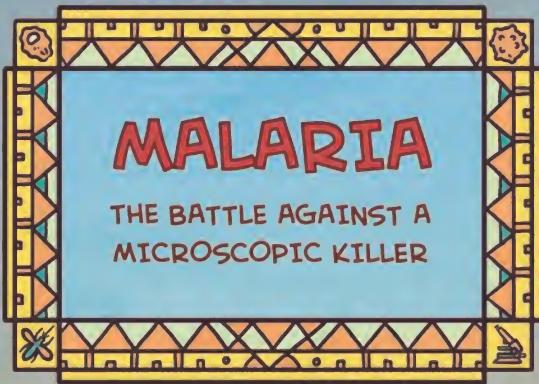
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ALL THE MOSQUITO WANTS IS A DROP OF YOUR BLOOD.

SHE CIRCLES IN...



SENSING CARBON DIOXIDE IN YOUR BREATH

THE HEAT OF YOUR BODY AS SHE APPROACHES



SEARCHING FOR THE BLOOD FILLED CAPILLARIES LYING JUST UNDER YOUR SKIN.



BUT THIS INSECT HAS BEEN HIJACKED BY MICROSCOPIC PARASITES CALLED PLASMODIUM.



THIS MEAL IS THEIR CHANCE TO SPREAD.

PLASMODIUM PARASITES SURGE DOWN THE MOSQUITO'S MOUTHPARTS AS SHE BITES, SLIPPING UNDETECTED INTO THE BLOOD.

BURROWING INTO THE LIVER, THEY SILENTLY MULTIPLY BEFORE BURSTING OUT AND INVADING THE BLOOD.



WAVES OF PARASITES WREAK HAVOC IN YOUR BODY. THE SYMPTOMS OF MALARIA TAKE HOLD.



NOW PLASMODIUM HAS HIJACKED YOU! AND IT'S READY TO BE PICKED UP AND PASSED ON BY THE NEXT MOSQUITO THAT BITES YOU.

MALARIA IS ONE OF HUMANKIND'S OLDEST FOES.

PEOPLE HAVE BEEN LIVING WITH AND DYING FROM THE DISEASE SINCE THE DAWN OF HISTORY.



FEVER AND SHIVERING.



IN DUSTY TOMES AND ANCIENT HISTORIES WE FIND REFERENCE TO A TERRIBLE SICKNESS.



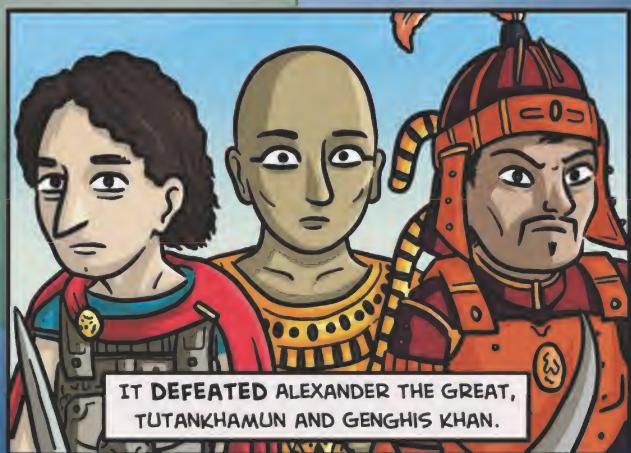
JOINT PAIN AND VOMITING.



CONVULSIONS AND DEATH.



IT IS A DISEASE THAT HAS SHAPED WORLD HISTORY. A KILLER OF KINGS AND WARLORDS.



IT DEFEATED ALEXANDER THE GREAT, TUTANKHAMUN AND GENGHIS KHAN.

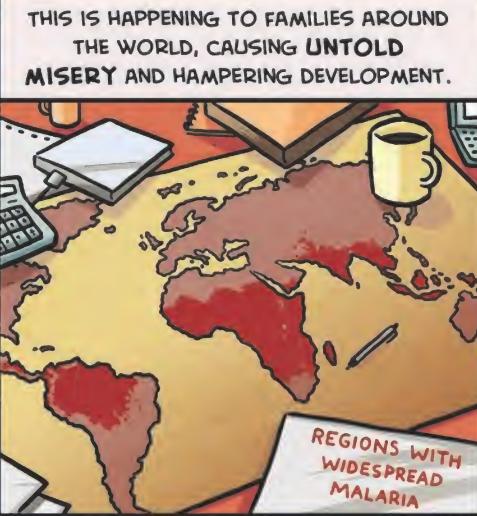
AND IT CONTINUES TO KILL TO THIS DAY.



MALARIA STRIKES MILLIONS, FROM GOLD MINERS TO GAP YEAR STUDENTS, FOOTBALLERS TO SOLDIERS.

HALF THE WORLD'S POPULATION IS AT RISK. IT HITS THE YOUNG, THE POOR AND THE VULNERABLE THE HARDEST.

EVEN IF A FARMER IS SICK FOR JUST A WEEK, IT HAS HUGE CONSEQUENCES WHEN HIS CROPS GO TO WASTE AND HIS FAMILY GOES HUNGRY.



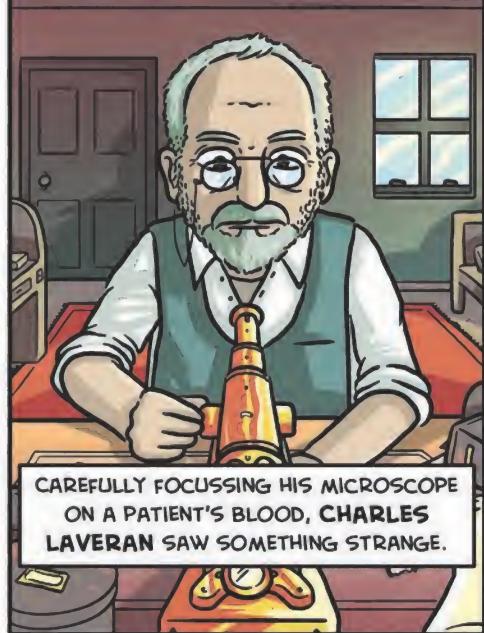
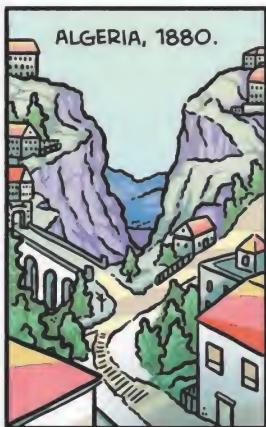
REGIONS WITH WIDESPREAD MALARIA

THIS IS HAPPENING TO FAMILIES AROUND THE WORLD, CAUSING UNTOLD MISERY AND HAMPERING DEVELOPMENT.

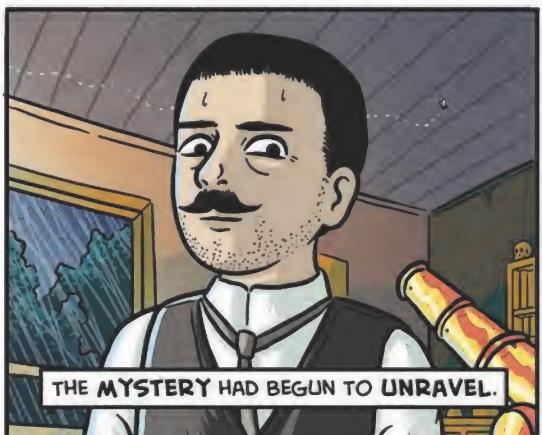
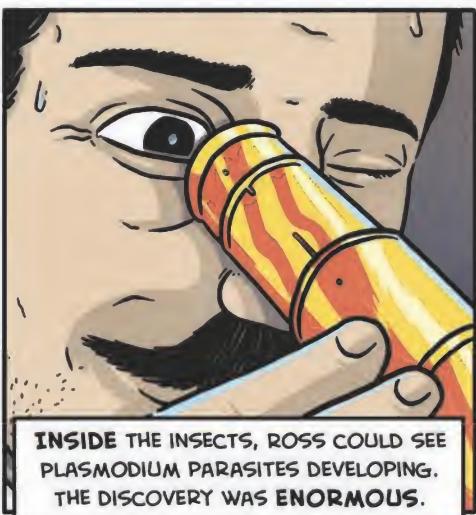
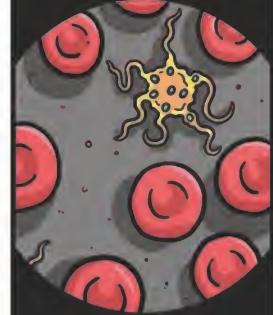


MALARIA IS ONE OF HUMANKIND'S DEADLIEST DISEASES. BUT THERE IS HOPE...

FOR CENTURIES  
PEOPLE HAVE BEEN  
TRYING TO BETTER  
UNDERSTAND THIS  
DEVASTATING ILLNESS.



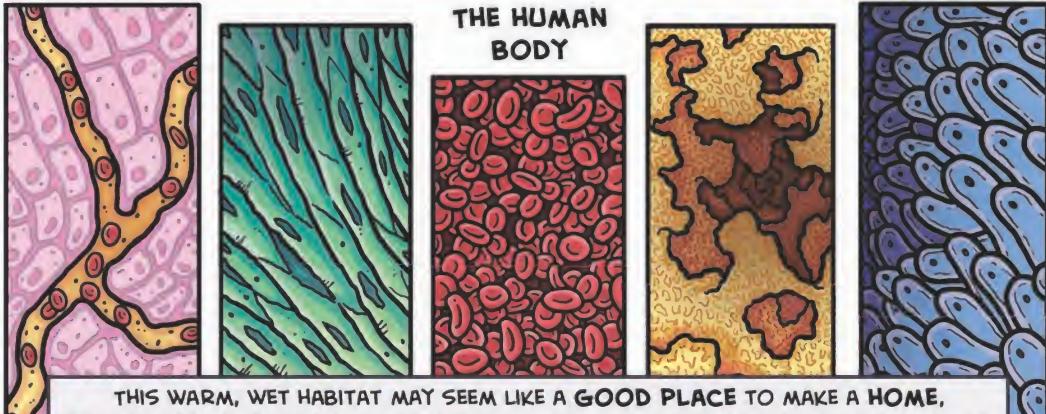
ALIEN-LOOKING  
MICROBES THRASHING  
ABOUT... FINALLY  
HUMANS WERE  
FACE-TO-FACE WITH  
THIS ANCIENT FOE.



THIS WORK CONTINUES TODAY. TOP SCIENTISTS ACROSS EUROPE ARE PART OF A GLOBAL EFFORT TO UNDERSTAND AND ERADICATE MALARIA. TO DO THAT WE NEED TO ANSWER SOME FUNDAMENTAL QUESTIONS ABOUT PLASMODIUM.

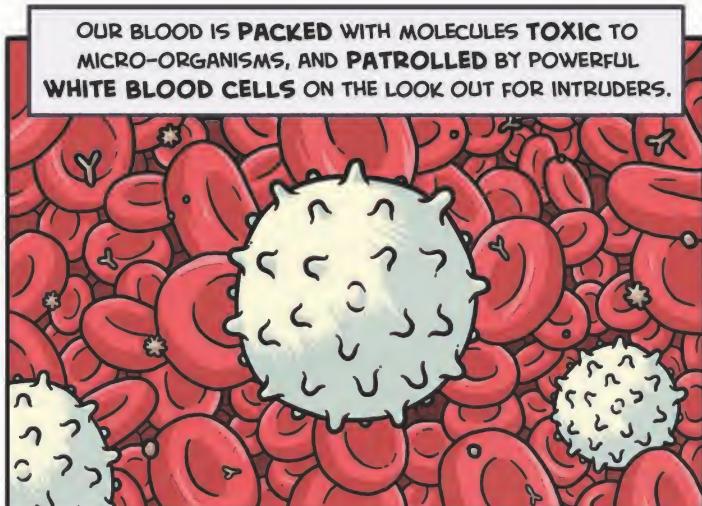
HOW DO THESE PARASITES SURVIVE AND MULTIPLY? WHY DON'T OUR BODIES STOP THEM? WHAT CAN WE DO TO REDUCE THE MISERY THAT MALARIA CAUSES?

THE HUMAN BODY



THIS WARM, WET HABITAT MAY SEEM LIKE A GOOD PLACE TO MAKE A HOME, BUT TO MICROSCOPIC PARASITES IT IS A PARTICULARLY HOSTILE ENVIRONMENT.

OUR BLOOD IS PACKED WITH MOLECULES TOXIC TO MICRO-ORGANISMS, AND PATROLLED BY POWERFUL WHITE BLOOD CELLS ON THE LOOK OUT FOR INTRUDERS.

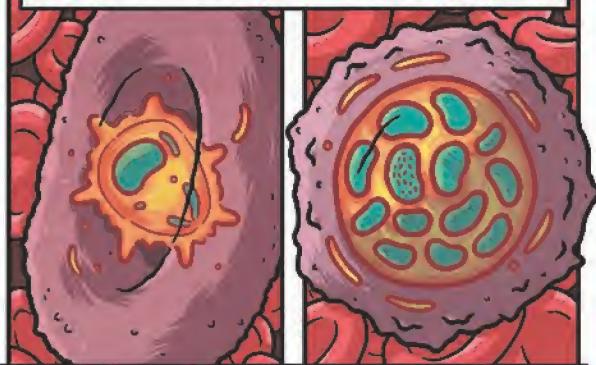


TO SURVIVE, PLASMODIUM NEEDS TO AVOID A FULL-ON BATTLE WITH OUR DEFENCES.

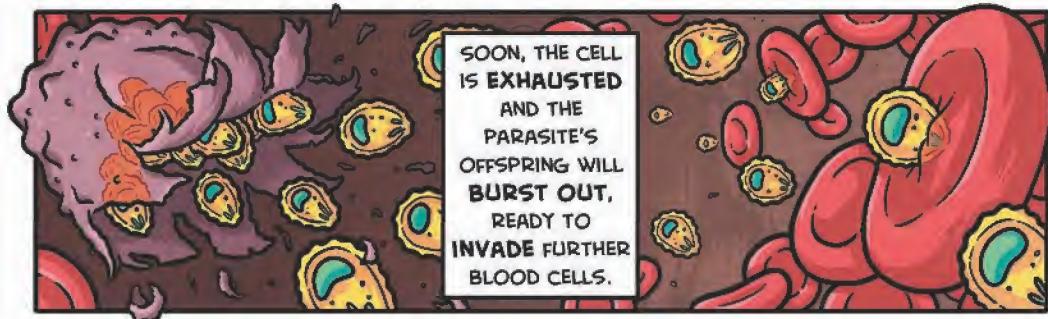
PLASMODIUM FORCES ITS WAY INSIDE OUR CELLS, FIRST IN THE LIVER AND THEN IN THE BLOOD.



HIDDEN FROM THE IMMUNE SYSTEM, THE PARASITE CAN MAKE ITSELF AT HOME, DEVOURING THE CELL CONTENTS AND CHANGING THE CELL'S STRUCTURE.



THE ENSLAVED CELL NOW SERVES THE PARASITE, FEEDING IT WITH NUTRIENTS TO GROW AND MULTIPLY.

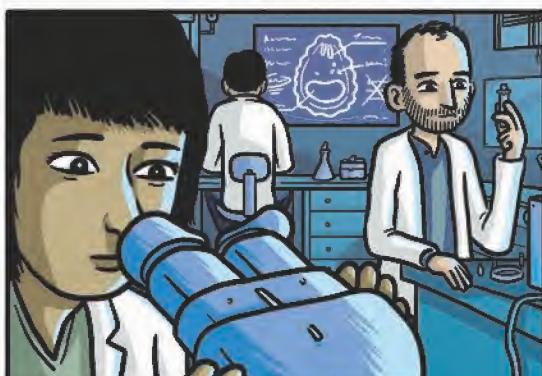


SOON, THE CELL IS EXHAUSTED AND THE PARASITE'S OFFSPRING WILL BURST OUT, READY TO INVADE FURTHER BLOOD CELLS.

THIS DEADLY CYCLE PLAYS OUT IN EVERY CASE OF MALARIA. AS THE PARASITES PROSPER, THE PATIENT WEAKENS.



BY LEARNING WHAT PLASMODIUM NEEDS TO LIVE ITS LIFE, WE GATHER CLUES ABOUT THE WAYS WE CAN STOP IT.



TOGETHER, THE WORLD'S SCIENTISTS ARE BUILDING UP A PICTURE OF THESE ORGANISMS, ONE PUZZLE PIECE AT A TIME.

IT MAY BE MICROSCOPIC, BUT PLASMODIUM HAS THE SAME NEEDS AS OTHER CREATURES.



IT NEEDS ENERGY.



A WAY OF SENSING  
ITS SURROUNDINGS.



WAYS TO ESCAPE  
FROM PREDATORS.



A WAY TO REPRODUCE  
AND SPREAD.

POWERFUL MICROSCOPES ALONE  
WILL NOT SHOW US HOW THESE  
PROCESSES REALLY WORK.

TO UNDERSTAND PLASMODIUM'S INNER WORKINGS,  
WE MUST TURN TO ITS GENES: THE INSTRUCTIONS  
OF HOW ITS DIFFERENT PARTS ARE BUILT AND REPAIRED.



IN THE LAB WE CAN DELETE GENES AND SEE WHAT  
HAPPENS. BY DELETING JUST ONE GENE WE CAN TRICK  
THE INVADING PARASITE INTO THINKING IT IS SAFELY INSIDE A  
LIVER CELL, LEAVING IT EXPOSED TO OUR IMMUNE SYSTEM.

BY REMOVING ONE PIECE AT A  
TIME WE CAN BUILD A PICTURE  
OF WHAT EACH PIECE DOES, AND  
HOW THEY ALL INTERACT.



I'M TRYING TO UNDERSTAND HOW PARASITES BREAK INTO CELLS, BUT THESE ORGANISMS ARE SO TRANSPARENT AND TINY THAT THEY'RE VERY DIFFICULT TO SEE.



THE CRYSTAL JELLYFISH PRODUCES MOLECULES ALLOWING IT TO GLOW IN THE OCEAN DEPTHS.



WE CAN TAKE THIS GENE FROM THE JELLYFISH AND ATTACH IT TO THE PLASMODIUM GENES WE'RE INTERESTED IN.

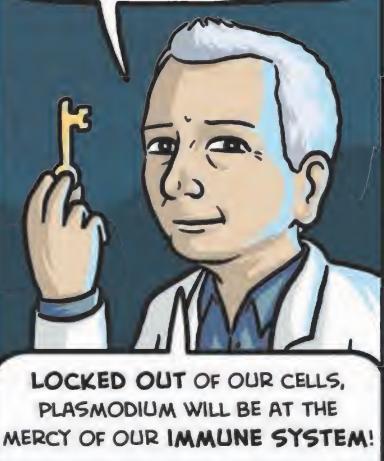


THE MODIFIED PARASITES LIGHT UP TO REVEAL THEIR INNER WORKINGS.

IT'S A SPECTACULAR NEON LIGHT SHOW, BUT USEFUL TOO. WE CAN NOW CLEARLY SEE THE DIFFERENT PARTS OF THE PARASITE, AND HOW THEY INTERACT AS PLASMODIUM LOCKPICKS ITS WAY INTO OUR CELLS.



IF WE WORK OUT HOW THIS PROCESS WORKS, PERHAPS WE CAN FIND WAYS TO BLOCK IT.



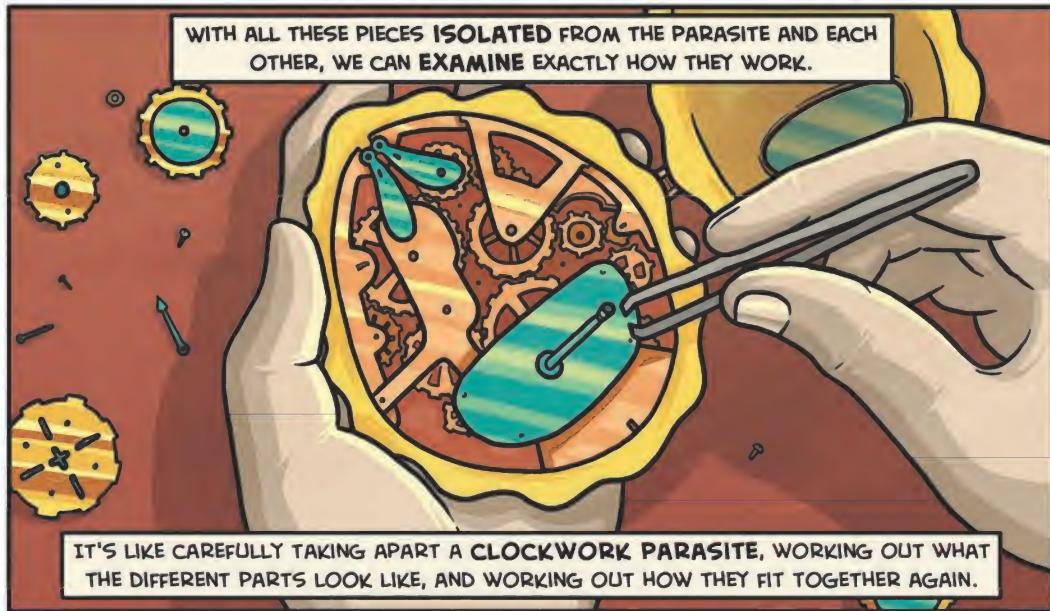
LOCKED OUT OF OUR CELLS, PLASMODIUM WILL BE AT THE MERCY OF OUR IMMUNE SYSTEM!

TO INVESTIGATE EACH SEPARATE PART OF PLASMODIUM, WE CAN PUT THEIR GENES IN MICROBES THAT ARE EASIER TO GROW, LIKE BACTERIA OR YEAST.

LIKE MICROSCOPIC FACTORIES, THESE ENGINEERED MICROBES WILL CHURN OUT LARGE QUANTITIES OF THE PLASMODIUM COMPONENTS, WHICH CAN THEN BE EASILY PURIFIED AND EXAMINED.



WITH ALL THESE PIECES ISOLATED FROM THE PARASITE AND EACH OTHER, WE CAN EXAMINE EXACTLY HOW THEY WORK.



IT'S LIKE CAREFULLY TAKING APART A CLOCKWORK PARASITE, WORKING OUT WHAT THE DIFFERENT PARTS LOOK LIKE, AND WORKING OUT HOW THEY FIT TOGETHER AGAIN.

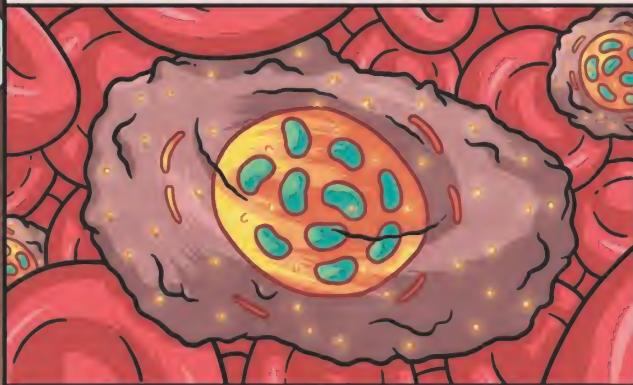
ALL THIS INFORMATION GIVES US A DETAILED PICTURE OF WHAT MAKES OUR ENEMY TICK, AND SUGGESTS WAYS WE MIGHT MAKE NEW TREATMENTS AND VACCINES TO THROW A SPANNER IN THE WORKS.





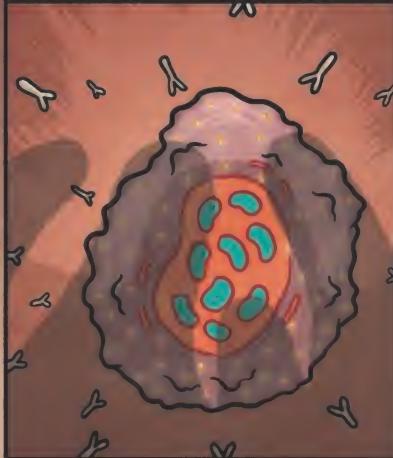
OUR OWN IMMUNE SYSTEMS  
COULD BE OUR MOST POWERFUL  
WEAPON AGAINST PLASMODIUM.

TO MULTIPLY, THE PARASITE MUST ADD TINY MARKERS  
TO THE RED BLOOD CELL SURFACE, ALLOWING IT TO  
COLLECT NUTRIENTS AND RESPOND TO ITS SURROUNDINGS.

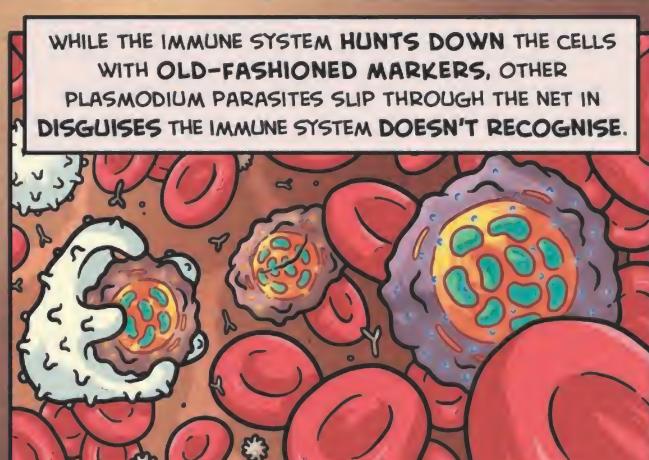


THESE MARKERS ARE A SIGN THAT THE RED BLOOD CELL  
HAS BEEN INFECTED, AND THEY WILL EVENTUALLY BE  
SPOTTED BY THE EVER-ADAPTING IMMUNE SYSTEM.

THE IMMUNE SYSTEM STRIKES!  
ANTIBODIES AND WHITE BLOOD  
CELLS SWOOP IN TO DESTROY  
THE CELL AND ITS DEADLY CARGO.



BUT PLASMODIUM HAS A  
STRATEGY TO ESCAPE. JUST  
AS FASHIONS DIFFER AMONGST  
PEOPLE, THESE MARKERS VARY  
AMONGST PARASITES.



WHILE THE IMMUNE SYSTEM HUNTS DOWN THE CELLS  
WITH OLD-FASHIONED MARKERS, OTHER  
PLASMODIUM PARASITES SLIP THROUGH THE NET IN  
DISGUISES THE IMMUNE SYSTEM DOESN'T RECOGNISE.



AS LONG AS THESE DISGUISES KEEP ON CHANGING,  
THE IMMUNE SYSTEM IS ALWAYS LEFT ONE STEP BEHIND.

A MALARIA VACCINE WOULD TRAIN THE IMMUNE SYSTEM TO RECOGNIZE PLASMODIUM AS SOON AS IT ARRIVES IN THE BODY.



IT COULD DESTROY THE PARASITE BEFORE ANY DAMAGE WAS DONE.

WE KNOW THAT THESE WEAK SPOTS EXIST. PEOPLE LIVING IN AREAS WITH HIGH LEVELS OF MALARIA BECOME MORE RESISTANT AS THEY GET OLDER.



BY STUDYING HOW OUR IMMUNE SYSTEMS RESPOND TO PLASMODIUM, WE ARE LEARNING HOW IMMUNITY TO THE PARASITE DEVELOPS.



THIS WILL HELP US MAKE BETTER, MORE POWERFUL VACCINES.

WHEN IT COMES TO CONTROLLING THE MICROSCOPIC PLASMODIUM, IT IS OFTEN EASIER TO TARGET THE MOSQUITOES THAT CARRY THEM.



MOSQUITOES ARE A CRITICAL STAGE IN THE PARASITE'S LIFECYCLE.

STOP THE MOSQUITO, STOP THE PARASITE.

DRAINING SWAMPS AND COVERING STANDING WATER WHERE MOSQUITOES BREED, USING INSECTICIDE-TREATED BEDNETS...

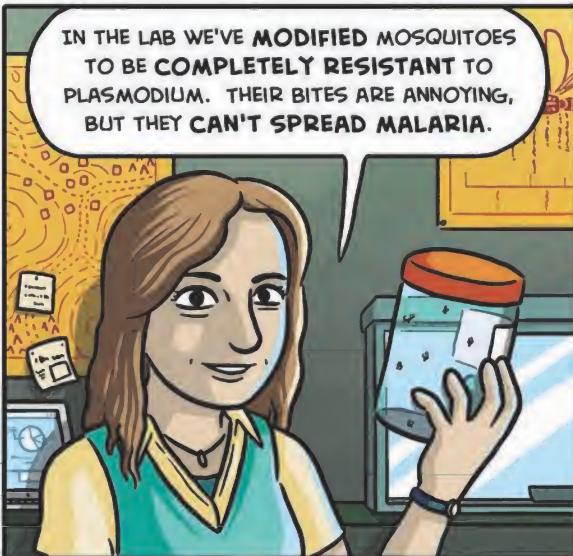


ALL THIS DENIES PLASMODIUM THE MOSQUITOES IT NEEDS TO HITCH A RIDE INTO OUR BODIES.

WE CAN ALSO OPEN UP NEW AVENUES OF ATTACK BY INVESTIGATING THE COMPLEX RELATIONSHIP BETWEEN MOSQUITO AND PARASITE.



IN THE LAB WE'VE MODIFIED MOSQUITOES TO BE COMPLETELY RESISTANT TO PLASMODIUM. THEIR BITES ARE ANNOYING, BUT THEY CAN'T SPREAD MALARIA.



BY TAKING THE BATTLE TO THE MOSQUITO, WE COULD HALT PLASMODIUM BEFORE IT GETS UNDER OUR SKIN.

BUT HUMANS ARE NOT THE ONLY ORGANISMS TRYING TO SURVIVE.



EVERY PUSH WE MAKE, THE PARASITES PUSH BACK.



IN THE 1950s, MALARIA ERADICATION SEEMED FEASIBLE. WE HAD POWERFUL TOOLS: THE POTENT ANTI-MALARIAL DRUG CHLOROQUINE, AND THE EFFECTIVE INSECTICIDE DDT.



UNFORTUNATELY, OUR POWER OVER THE PARASITE DIDN'T LAST FOR LONG.

WE WERE READY TO WIPE MALARIA OUT, AND IN SOME REGIONS WE HAD ALREADY SUCCEEDED.



THE PROBLEM IS THAT NO MATTER HOW EFFECTIVE A TREATMENT IS IN THE LAB, COMPLICATIONS EMERGE WHEN THESE TREATMENTS ENTER THE REAL WORLD.



GIVEN THE OPPORTUNITY, EVEN A SMALL AMOUNT OF RESISTANCE IN THE PARASITE POPULATION GIVES PLASMODIUM A CHANCE TO SURVIVE.

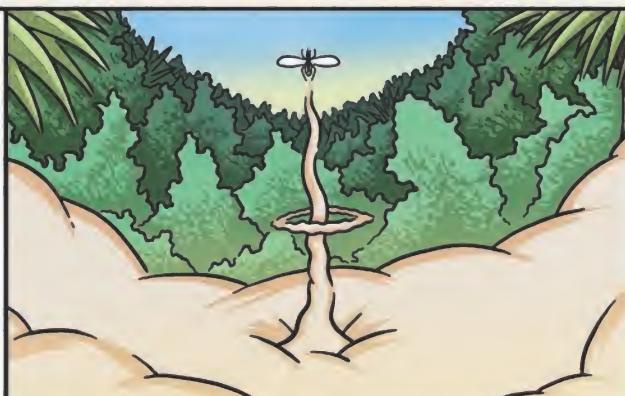


OVER TIME, THIS FIGHT FOR SURVIVAL AMPLIFIES THE RESISTANCE AND A NEW STRAIN OF RESISTANT PARASITES EMERGES.

IF WE'RE NOT CAREFUL, OUR PROMISING TREATMENTS RAPIDLY BECOME USELESS IN THE FACE OF A NEWLY RESISTANT STRAIN.



WE'VE LEARNED THIS THE HARD WAY. PLASMODIUM IS NOW ALMOST COMPLETELY RESISTANT TO CHLOROQUINE, AND MOSQUITOES INCREASINGLY IMPERVIOUS TO DDT.



TO STAND A CHANCE OF GETTING THE UPPER HAND IN THE FUTURE, WE NEED TO UNDERSTAND MORE ABOUT HOW RESISTANCE DEVELOPS AND SPREADS.

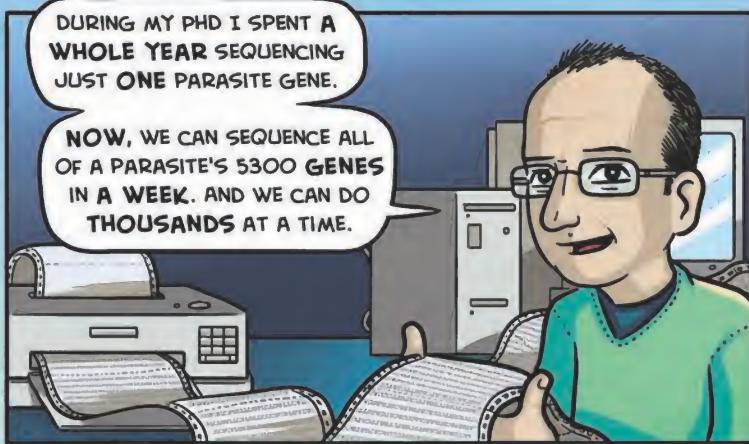


BY LOOKING AT PLASMODIUM'S GENES, WE ARE BEGINNING TO UNDERSTAND HOW IT EVOLVES. ACCESS TO THIS INFORMATION IS BECOMING EASIER AND EASIER.

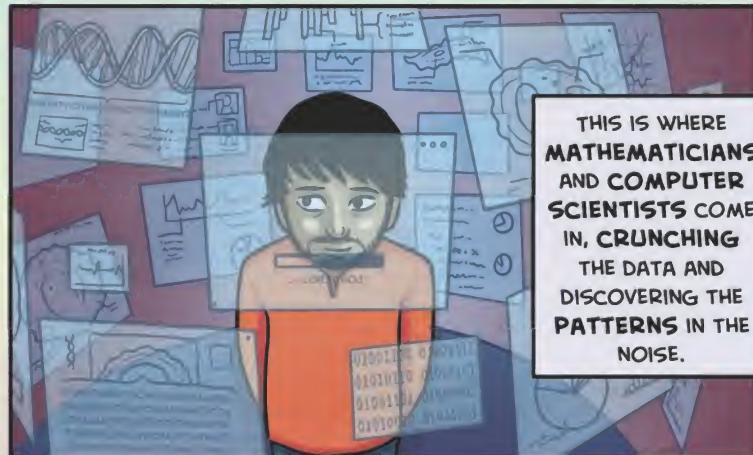


DURING MY PHD I SPENT A WHOLE YEAR SEQUENCING JUST ONE PARASITE GENE.

NOW, WE CAN SEQUENCE ALL OF A PARASITE'S 5300 GENES IN A WEEK. AND WE CAN DO THOUSANDS AT A TIME.



THE DATA IS POURING IN. THE DIFFICULTY IS GETTING MEANINGFUL ANSWERS FROM IT.



THIS IS WHERE MATHEMATICIANS AND COMPUTER SCIENTISTS COME IN, CRUNCHING THE DATA AND DISCOVERING THE PATTERNS IN THE NOISE.

WE LIVE IN A CHANGING WORLD, AND AS ECOSYSTEMS, MEDICINES AND HUMAN SOCIETIES CHANGE, WE SHOULDN'T BE SURPRISED THAT PARASITES CHANGE TOO.



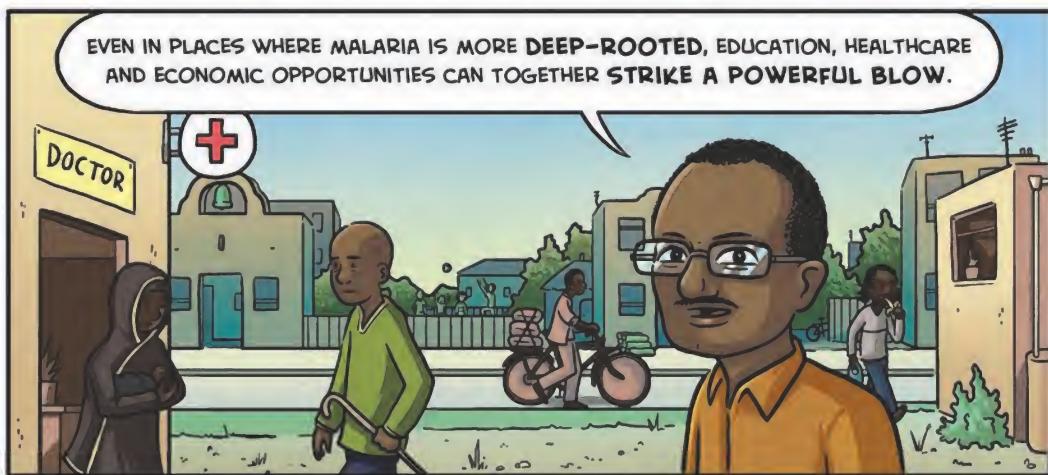
IF WE GATHER THE DATA AND LEARN HOW PARASITES ADAPT, AT LEAST THEN OUR FIGHT WILL BE WITH AN ENEMY WE UNDERSTAND.

MALARIA WAS ELIMINATED FROM EUROPE WITHOUT NEW DRUGS OR VACCINES. THE MAIN FORCE WAS ECONOMIC DEVELOPMENT.



DEFEATING MALARIA IS A CHALLENGE FOR MORE THAN JUST BIOLOGISTS. POLITICIANS, ECONOMISTS AND SOCIAL SCIENTISTS PLAY AN IMPORTANT ROLE TOO.

EVEN IN PLACES WHERE MALARIA IS MORE DEEP-ROOTED, EDUCATION, HEALTHCARE AND ECONOMIC OPPORTUNITIES CAN TOGETHER STRIKE A POWERFUL BLOW.



BUT MALARIA LEAVES THE PEOPLE WHO DRIVE A COMMUNITY'S DEVELOPMENT BEDRIDDEN.



BY REDUCING THE BURDEN OF MALARIA THE VICIOUS CYCLE CAN BE BROKEN.

PLASMODIUM IS A TERRIBLE FOE. IT'S AN ARMY OF BILLIONS, A GLOBAL THREAT WITH THE ABILITY TO EVOLVE RESISTANCE TO OUR WEAPONS.

IF WE WANT TO DEFEAT IT FOR GOOD, WE NEED ALL THE HELP WE CAN GET. THAT'S WHY WE ARE TRYING TO UNDERSTAND MALARIA FROM EVERY ANGLE:

THE PATIENT

THE INFECTED CELLS

THE MOSQUITO

THE IMMUNE SYSTEM

THE PARASITE



AS WE RESEARCH UNKNOWN ASPECTS OF THIS DREADFUL DISEASE, WE HOPE WE WILL REVEAL NEW WAYS OF PREVENTING AND CURING IT.

PUTTING A STOP TO MALARIA IS A MAMMOTH TASK.



THERE ARE NO EASY ANSWERS TO THE PROBLEMS THAT WE FACE.



BUT THE MORE WE LEARN ABOUT THIS MYSTERIOUS ORGANISM, THE BETTER OUR CHANCES OF SUCCESS.

THE EUROPEAN VIRTUAL INSTITUTE FOR MALARIA RESEARCH IS AN EXAMPLE OF SCIENTIFIC COLLABORATION IN ACTION.



THIS NETWORK CONNECTS SCIENTISTS ACROSS EUROPE AND BEYOND, WORKING TO EXPAND OUR KNOWLEDGE OF MALARIA.



REGULAR CONFERENCES  
BRING TOP THINKERS  
AND AMBITIOUS YOUNG  
RESEARCHERS TOGETHER  
IN ONE PLACE, TO DISCUSS  
FINDINGS AND SHARE IDEAS.

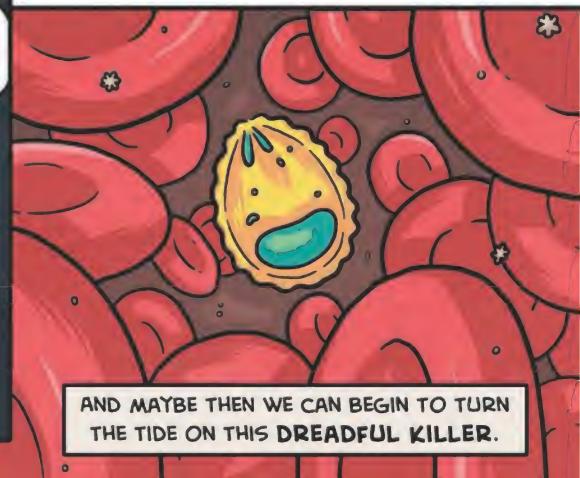


MEANWHILE, THE PROGRAMME WORKS TO TRAIN  
THE NEXT GENERATION OF MALARIA SCIENTISTS.



STUDENTS COMPLETE THEIR STUDIES ACROSS SEVERAL DIFFERENT LABS, GAINING SKILLS AND CONTACTS THAT WILL LAST A LIFETIME.

IT IS EFFORTS LIKE THESE THAT DRIVE OUR UNDERSTANDING OF MALARIA FORWARD AS A TRULY GLOBAL, CO-ORDINATED EFFORT.



AND MAYBE THEN WE CAN BEGIN TO TURN  
THE TIDE ON THIS DREADFUL KILLER.

MALARIA IS ONE OF HUMANKIND'S OLDEST AND DEADLIEST FOES. EVIMALAR IS A MALARIA RESEARCH NETWORK OF EXCELLENCE, FUNDED BY THE EUROPEAN COMMISSION CURRENTLY INVOLVING 62 GROUPS OF SCIENTISTS FROM INSTITUTES IN EUROPE, AFRICA, INDIA AND AUSTRALIA. ITS HEAD OFFICE IS AT THE UNIVERSITY OF GLASGOW IN THE UK. BY WORKING TOGETHER WE HOPE TO BETTER UNDERSTAND THE FUNDAMENTAL BIOLOGY OF THE PARASITE AND HOW THE PARASITE SUCCESSFULLY LIVES IN TWO VERY DIFFERENT ENVIRONMENTS: HUMANS AND MOSQUITOES. WE WILL THEN USE THIS KNOWLEDGE TO GENERATE NEW TOOLS TO FIGHT THE DISEASE.

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WITH THANKS TO ALL OUR INTERVIEWEES AND COLLABORATORS FROM THE EVIMALAR NETWORK AND THE SCIENTIFIC COMMUNITY. ADDITIONAL GRATITUDE TO MATT BERRIMAN AND SARAH REECE FOR ADVICE AND VISUAL RESOURCES. AND WITH SPECIAL THANKS TO ANDY WATERS, GILLIAN MURRAY AND HANSA PERTAB FOR ALL THEIR HELP.



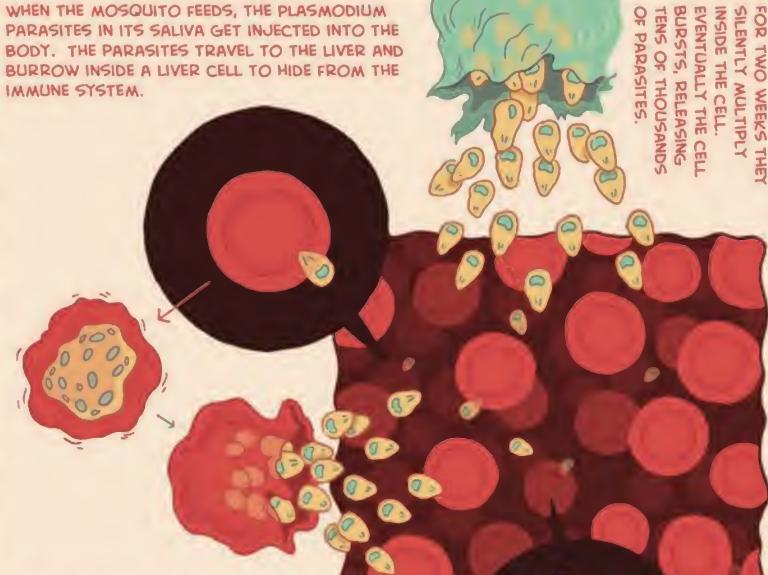


THE PARASITES MATURE AND MOVE TO THE SALIVARY GLANDS, READY TO BE INJECTED INTO THE NEXT HUMAN THAT IT BITES.

INSIDE THE MOSQUITO, THE PARASITES ESCAPE FROM THE GUT AND DEVELOP. THE MOSQUITO ITSELF IS NOW INFECTED.



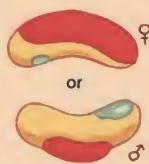
WHEN THE MOSQUITO FEEDS, THE PLASMODIUM PARASITES IN ITS SALIVA GET INJECTED INTO THE BODY. THE PARASITES TRAVEL TO THE LIVER AND BURROW INSIDE A LIVER CELL TO HIDE FROM THE IMMUNE SYSTEM.



THESE PARASITES LIVE IN THE BLOOD, INVADING RED BLOOD CELLS, MULTIPLYING, AND THEN BURSTING OUT TO INVADE FURTHER RED BLOOD CELLS.



WHEN THE MOSQUITO BITES AND DRINKS THE BLOOD, IT ALSO TAKES UP PARASITES.



## MALARIA: THE BATTLE AGAINST A MICROSCOPIC KILLER

MALARIA IS A TERRIBLE DISEASE, AND ONE OF HUMANKIND'S OLDEST AND DEADLIEST FOES. THIS COMIC EXPLORES OUR ONGOING BATTLE WITH THE PARASITE THAT CAUSES MALARIA, AND GOES INSIDE THE LABS AND CLINICS WHERE SCIENTISTS ARE WORKING TO PUT AN END TO THE MISERY THAT MALARIA CAUSES.

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